Impacts of Tropical Cyclones on the Upper Troposphere

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Impacts of Tropical Cyclones on the Upper Troposphere Using AIRS Products

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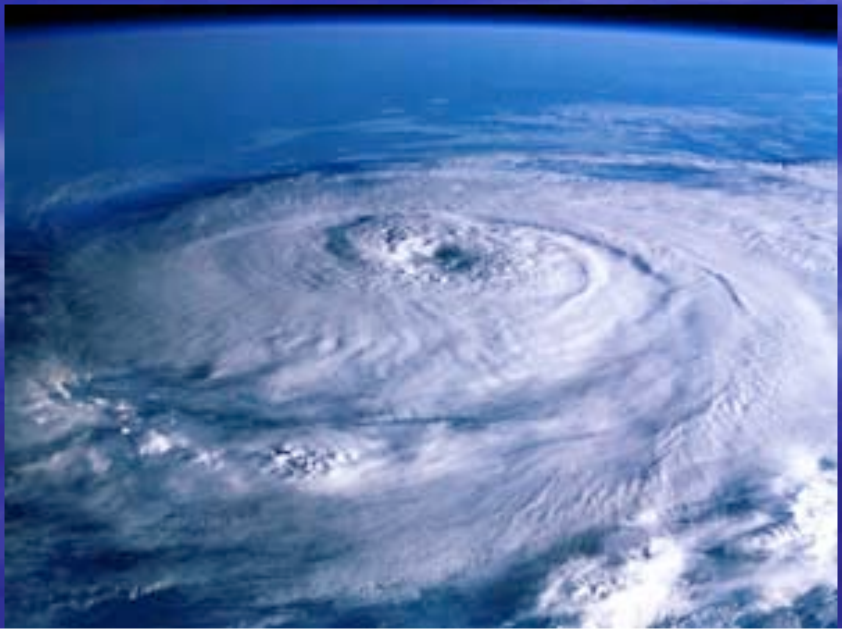
Motivation

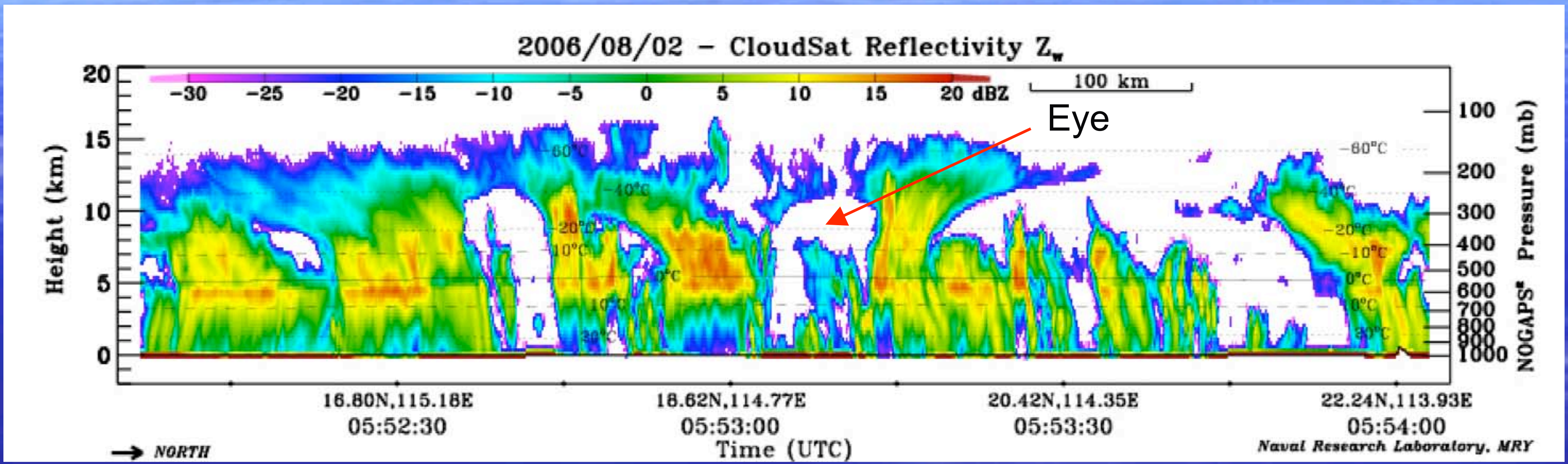
Why look at the impacts of TCs on the UT?

- TCs are potentially significant sources of trace gases and humidity to the UT through deep convection.
- The tropical UT plays an important role in the thermodynamic and radiative balance of the atmosphere.
- Changes in TC strength or number in future may produce feedbacks on climate.



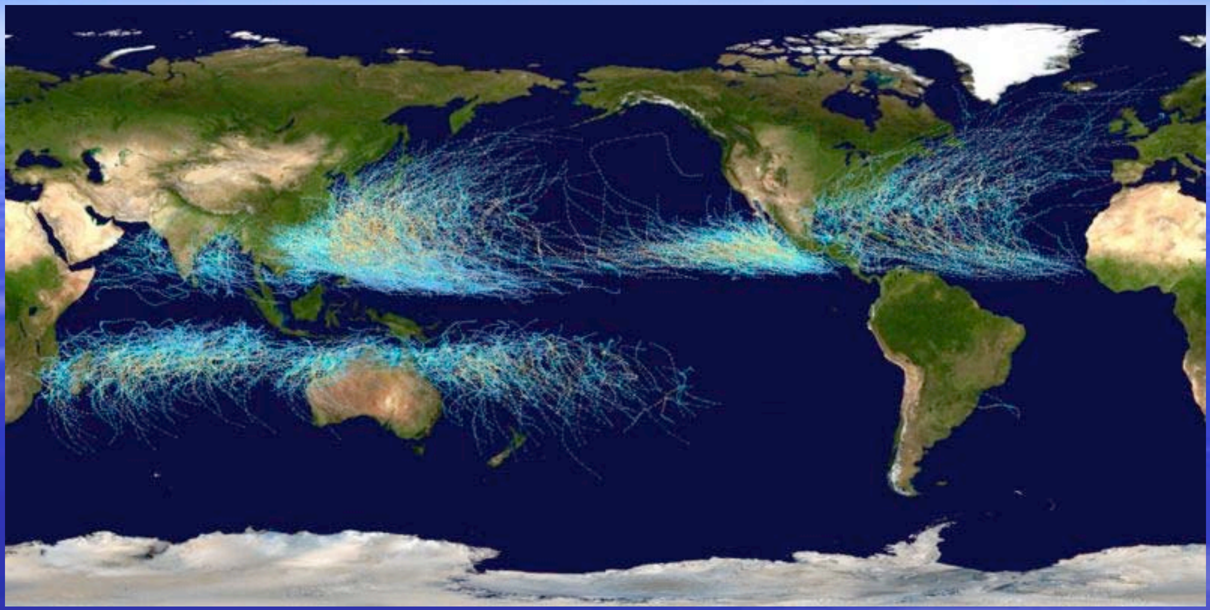
Convection in tropical cyclones

CloudSat View of Typhoon Prapiroon



- Tens to hundreds of kms in horizontal extent.
- Deepest near the eye.
- Multiple convective bands spiraling away from eye.
- Large scale outflow region in UT.

Tracks of Tropical Cyclones



Number of cyclones used in this study (Sep. 2002 to Oct. 2006)

	Intense	Weak
Atlantic	20	54
West Pacific	47	56
East Pacific	12	53
South Pacific	16	12
South Indian	21	45

Intense = category 3-5
Weak = TS - category 2

Data

AIRS

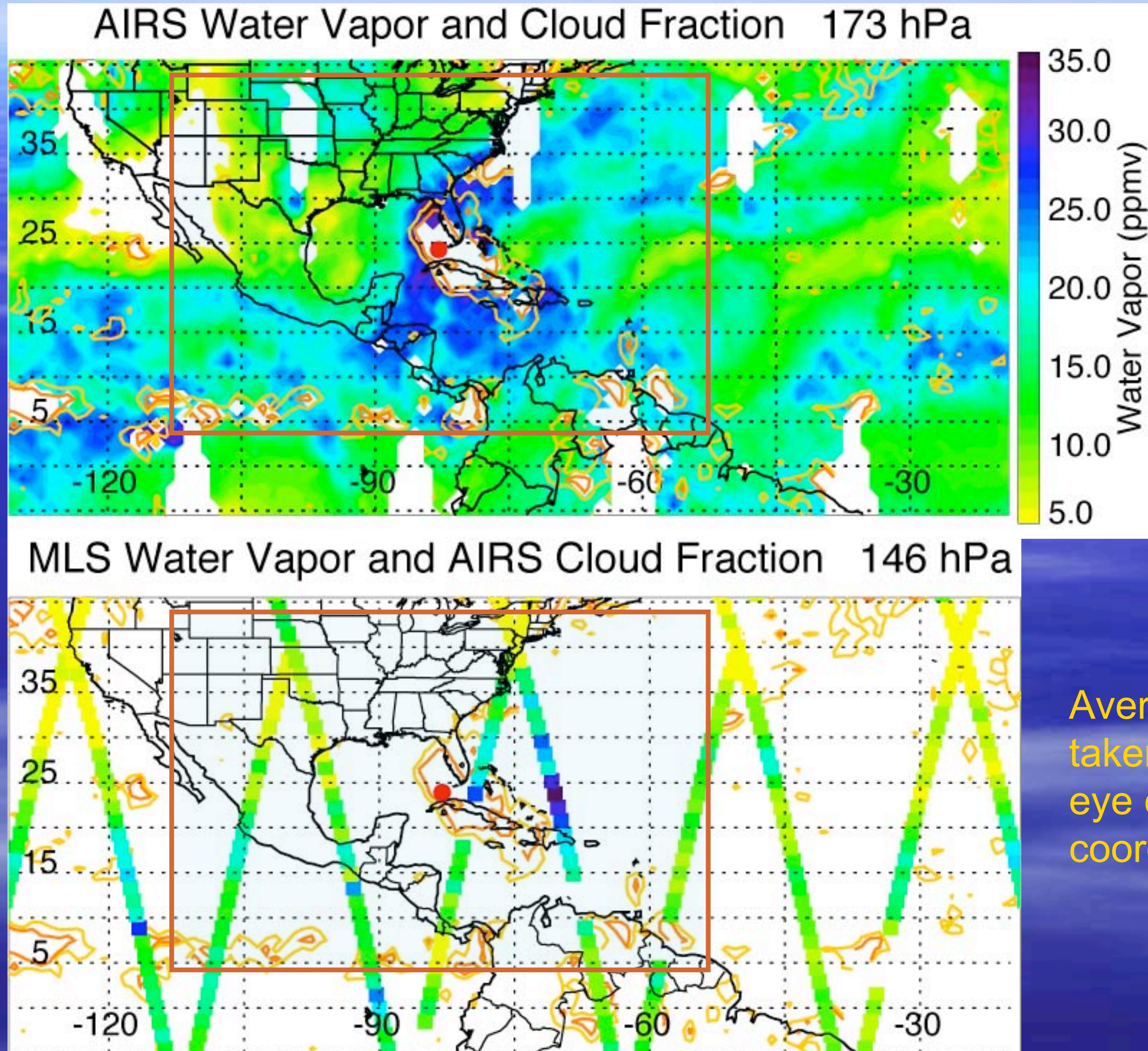
Primarily version 4, level 3 water vapor, cloud fraction and cloud top height.

Have started to use version 5 water vapor, cloud properties, CO and CH_4.

MLS

Version 1.51 water vapor

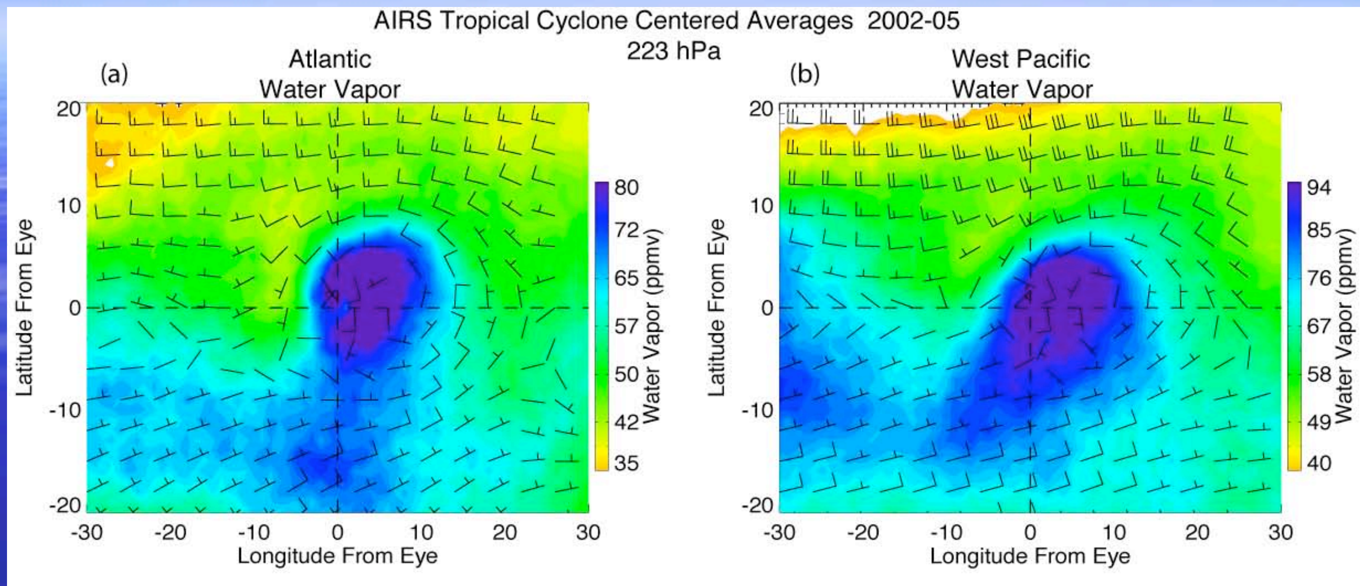
Hurricane Dennis July 9, 2005



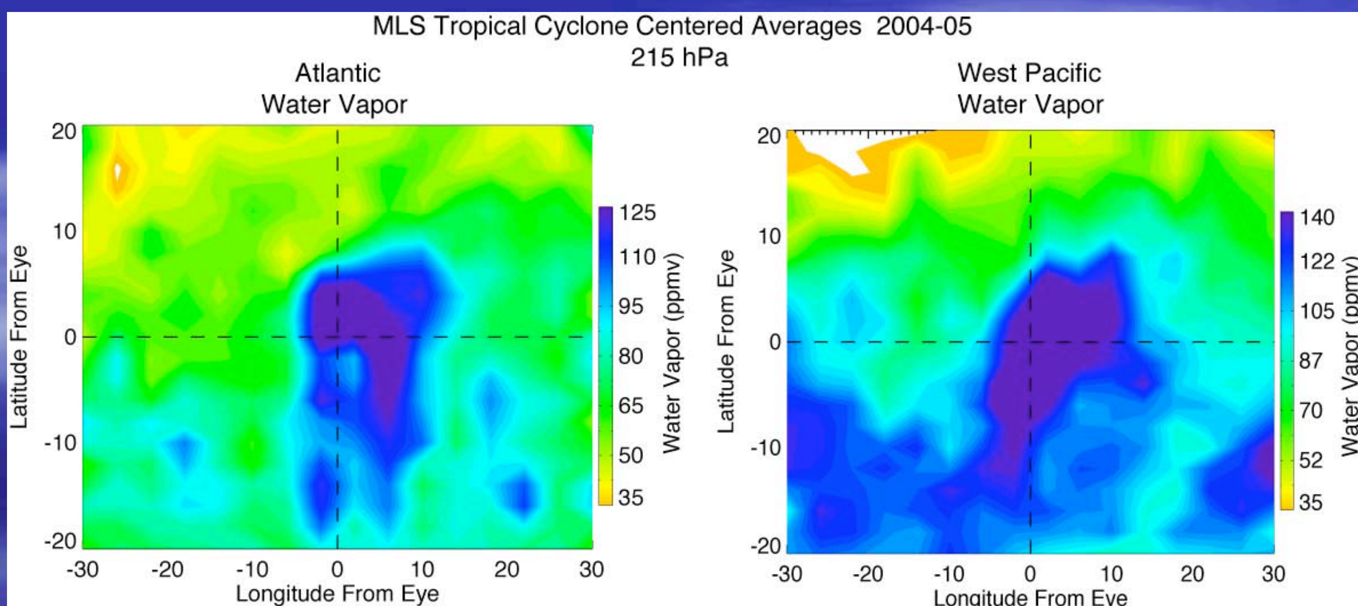
Averages are taken in a cyclone eye centered coordinate system

Cyclone-Centered AIRS and MLS Averages

AIRS



MLS



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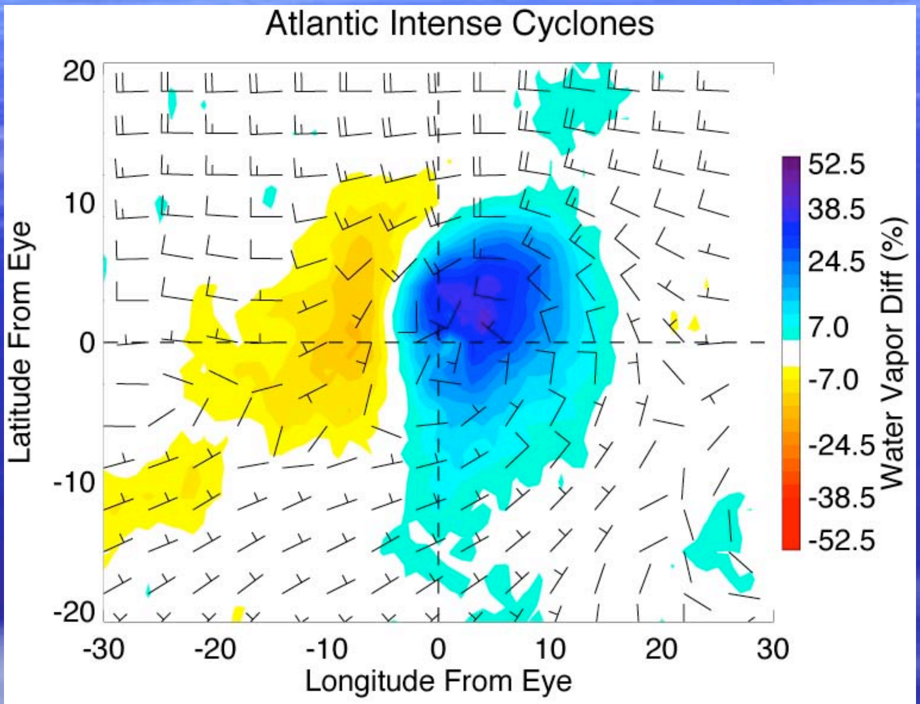
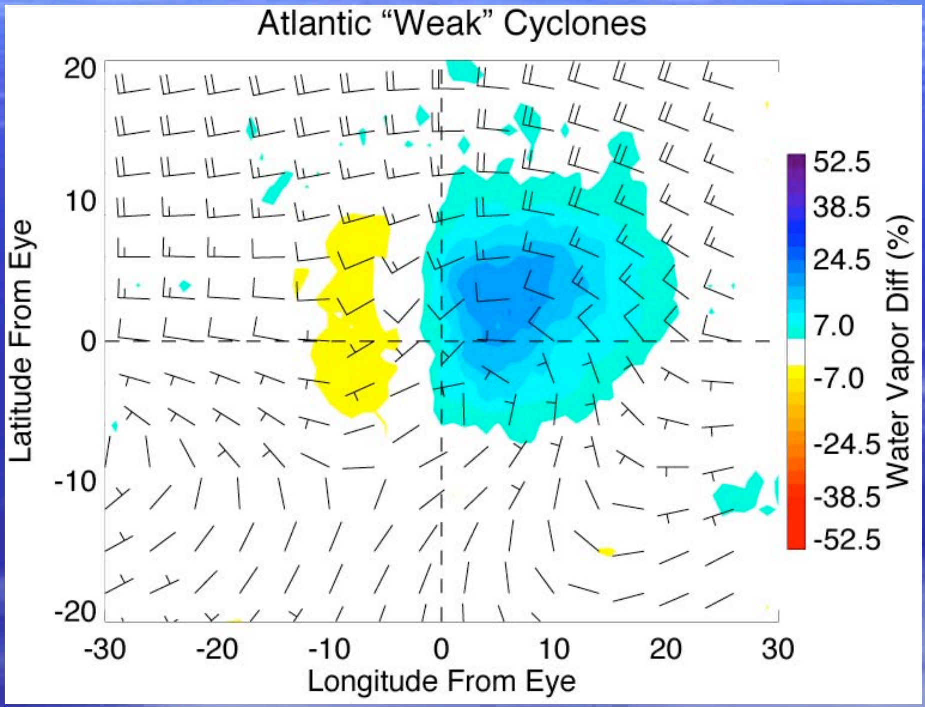
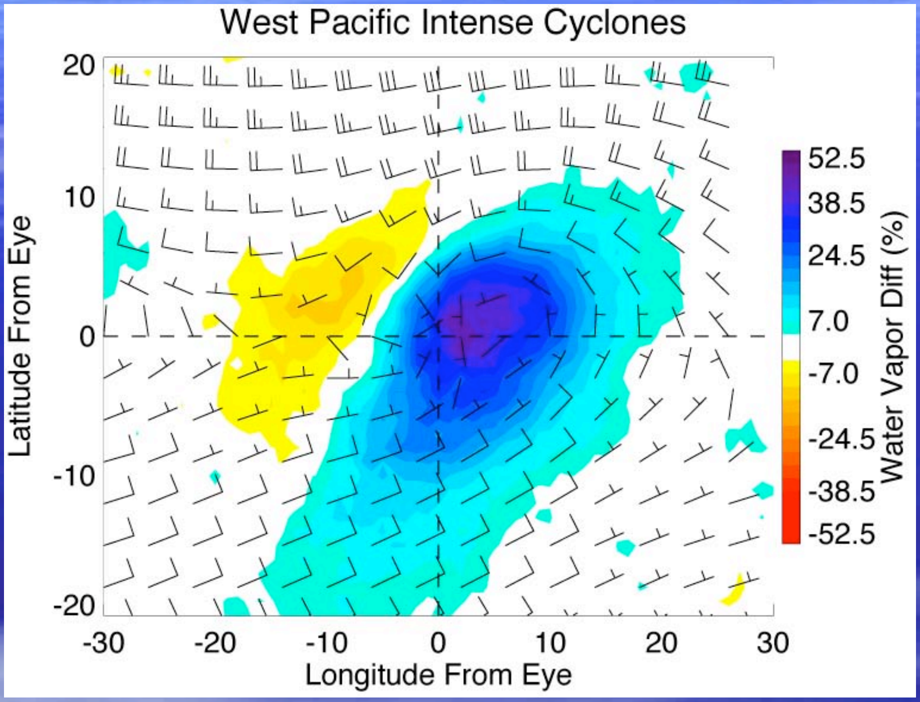
AIRS Average Water Vapor Differences From Monthly Means
Atlantic 173 hPa 2002-06

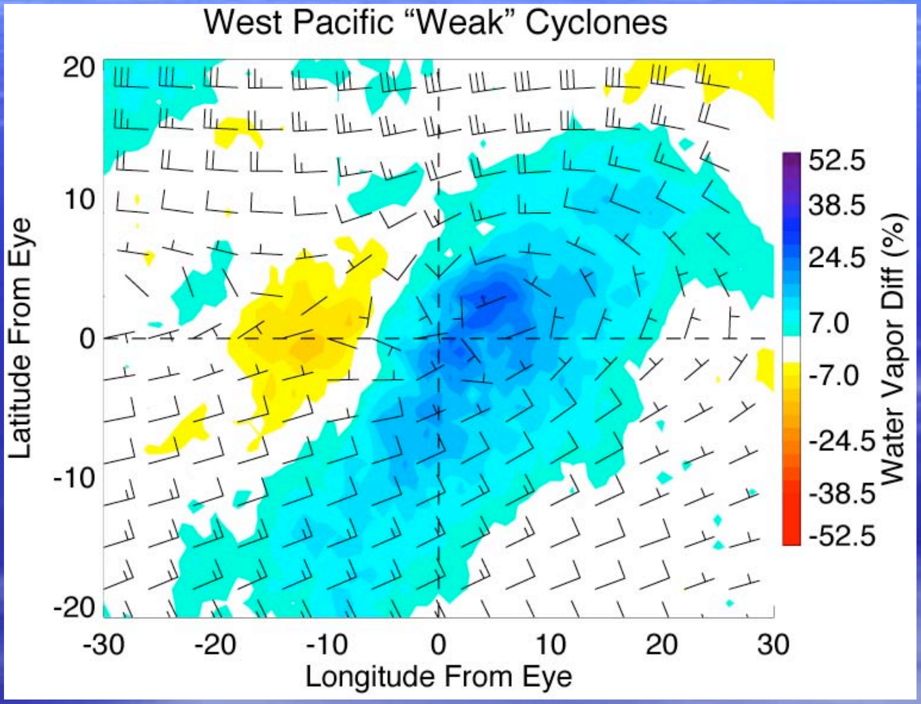




Large region of enhanced WV to the east of the eye.
But also a compensating region of low water to the west of the eye.

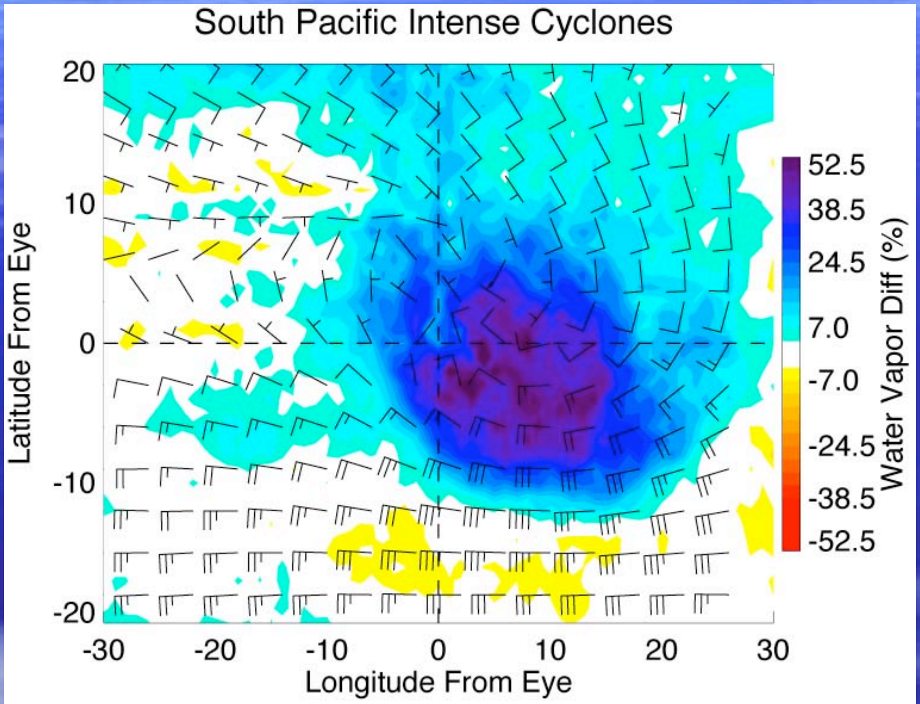
AIRS Average Water Vapor Differences From Monthly Means
West Pacific 173 hPa 2002-06

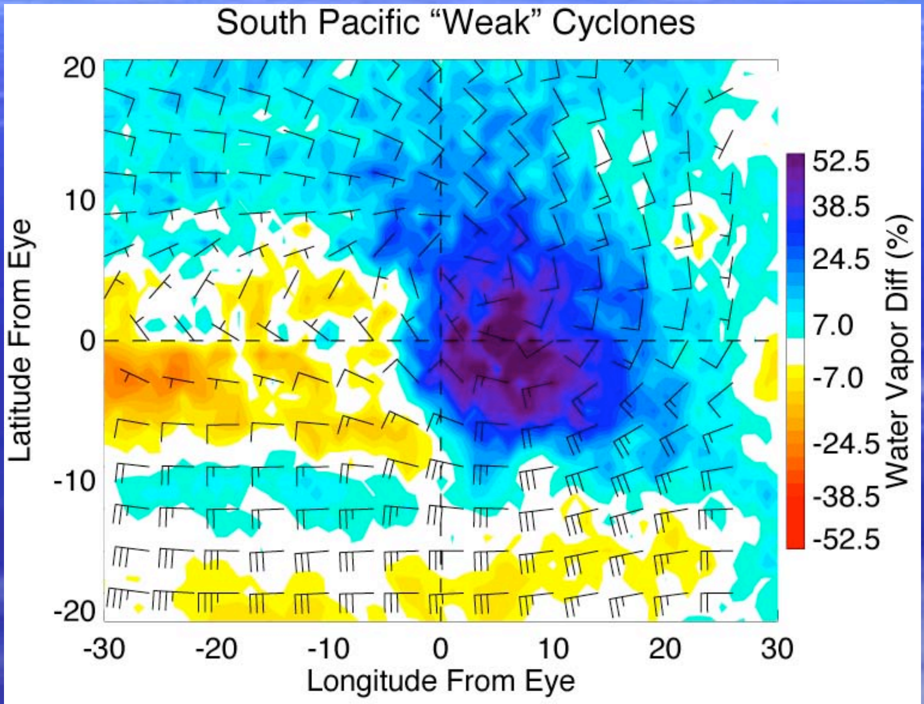




Larger region of enhanced WV compared to Atlantic.

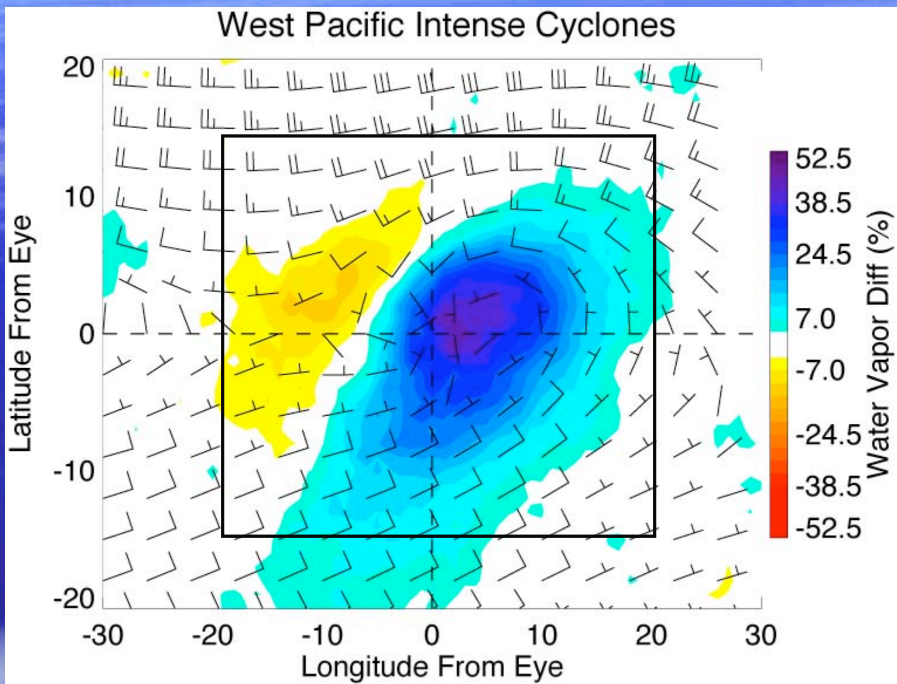
AIRS Average Water Vapor Differences From Monthly Means
South Pacific 173 hPa 2002-06

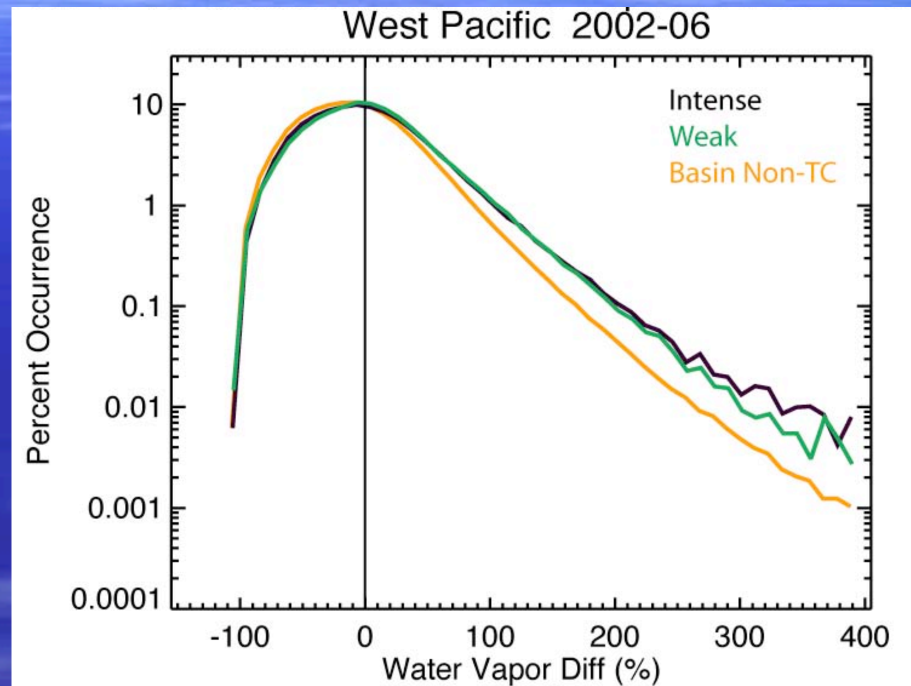




Region of enhanced WV is larger and values higher compared to NH TCs.

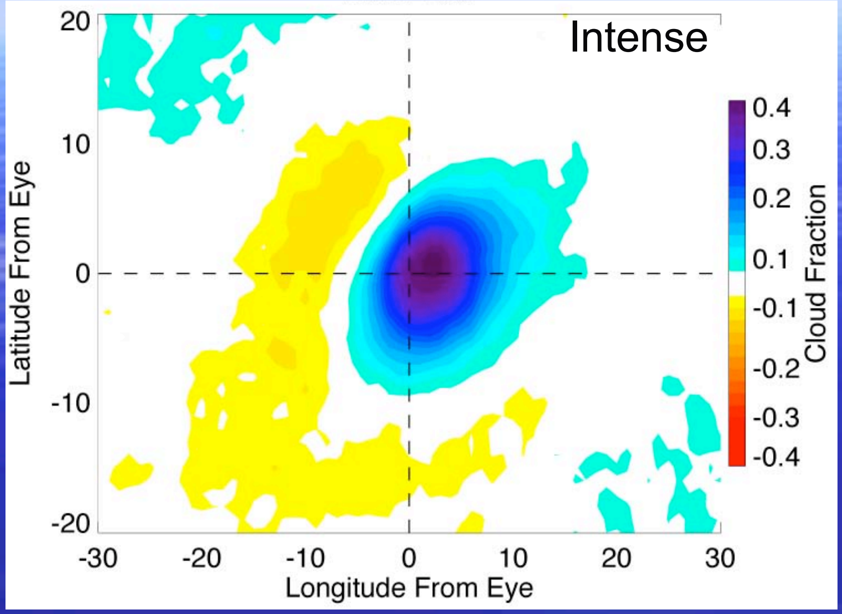
Probability Distributions of AIRS Water Vapor Differences
West Pacific 173 hPa 2002-06

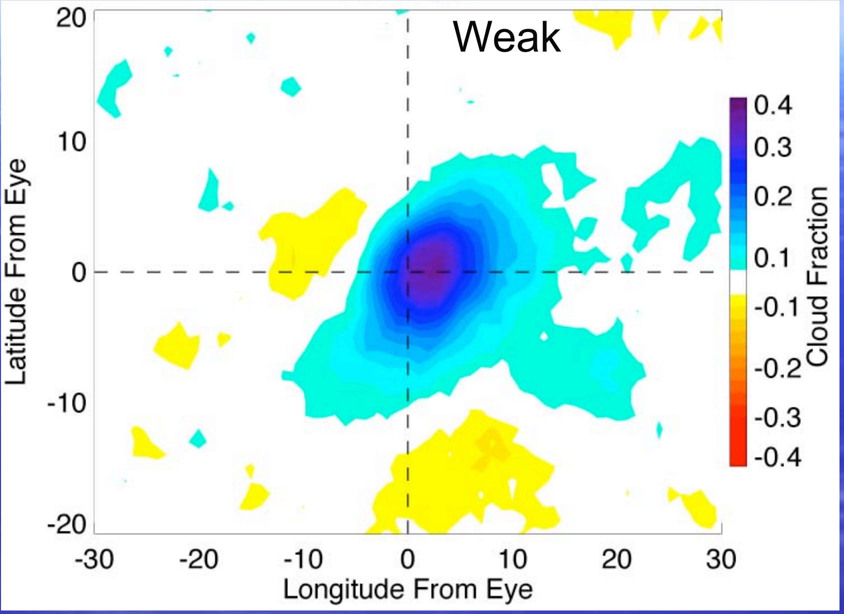


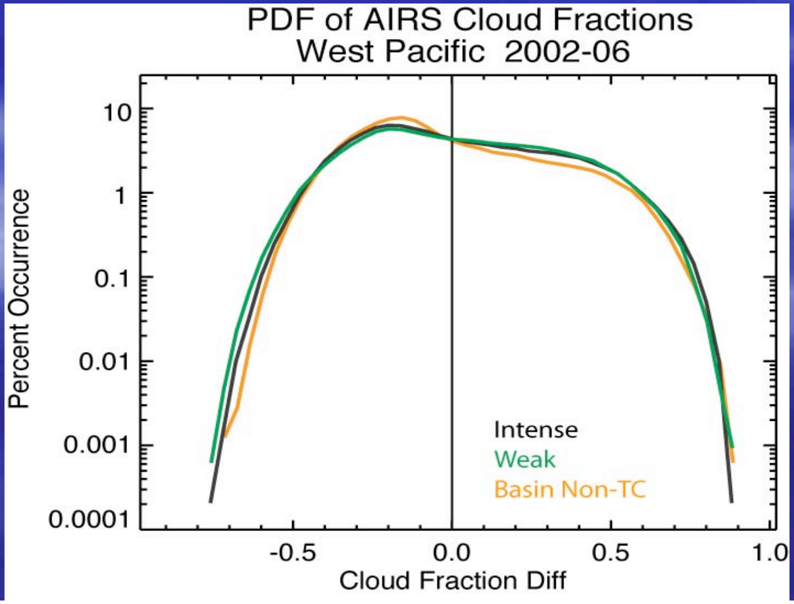


Basin Non-TC PDF includes days when a TC is not present from May-Nov in the West Pacific basin (110-180W, 0-30N)

AIRS Cloud Fraction Differences
West Pacific 2002-06

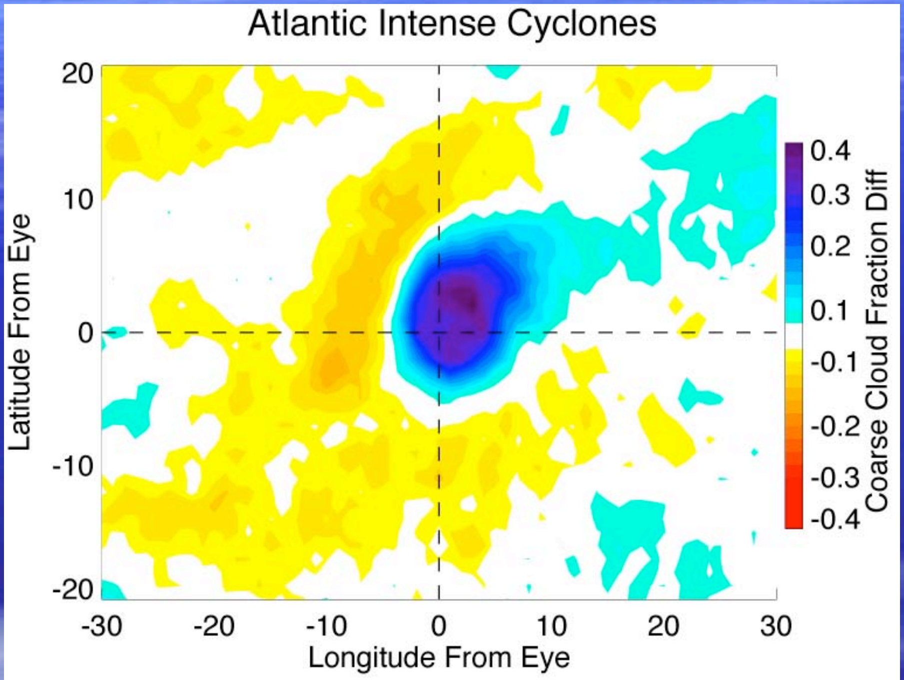


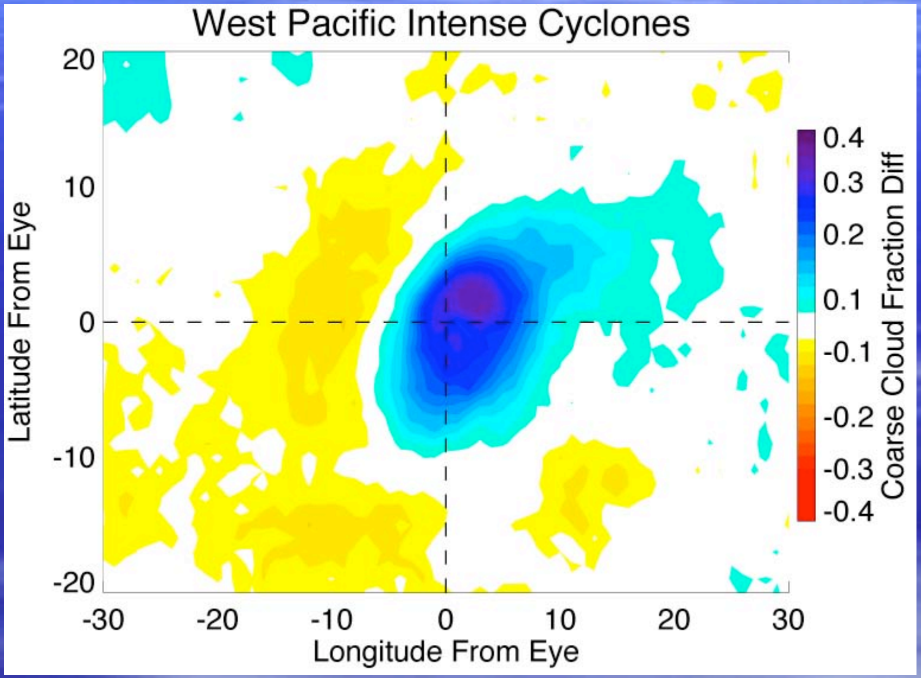




Higher probability of more clouds during TCs. Opposite of the "Iris effect"

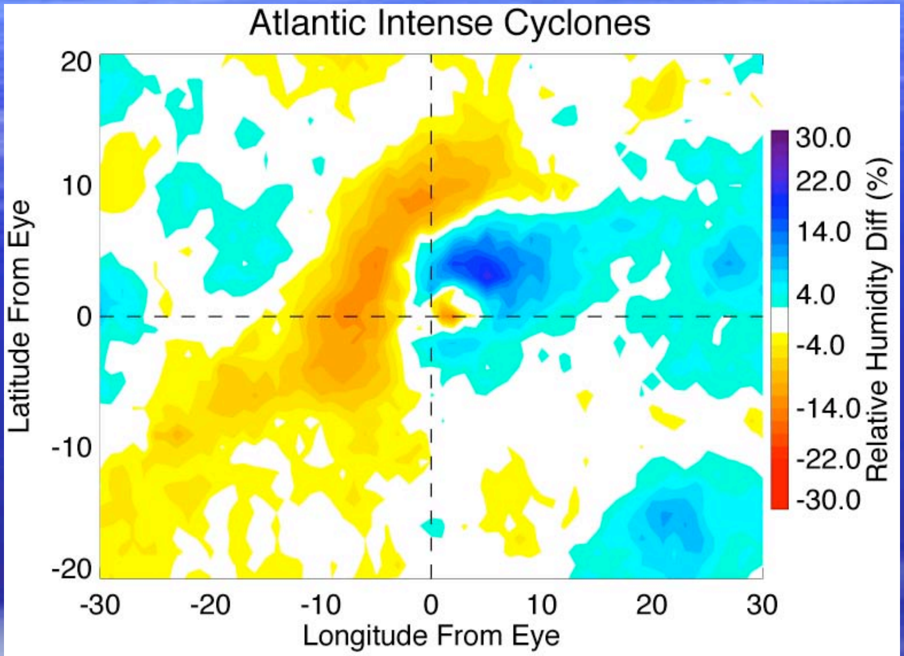
AIRS v5 Coarse Cloud Fraction Differences
High Level 2004-05

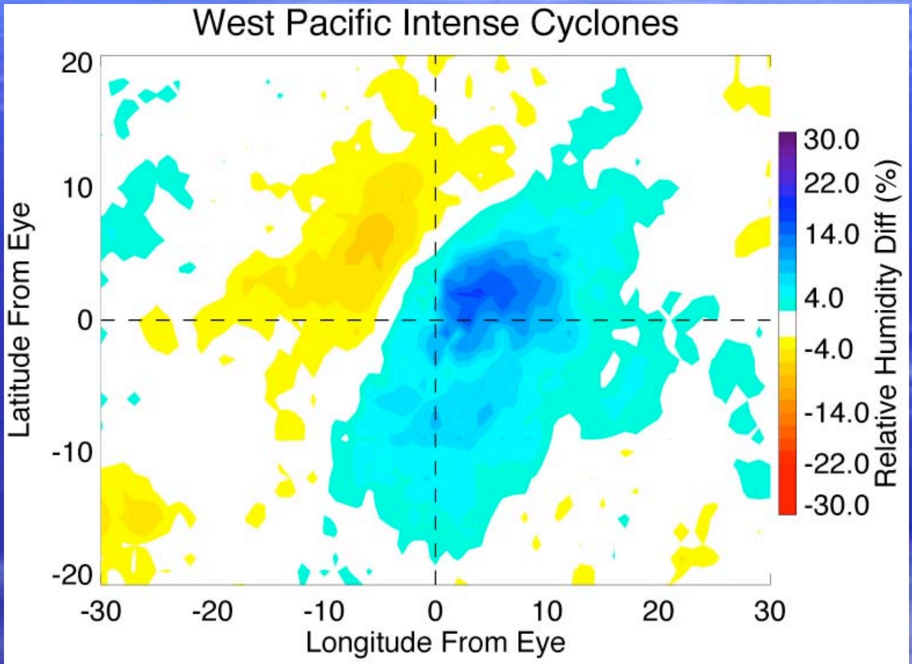




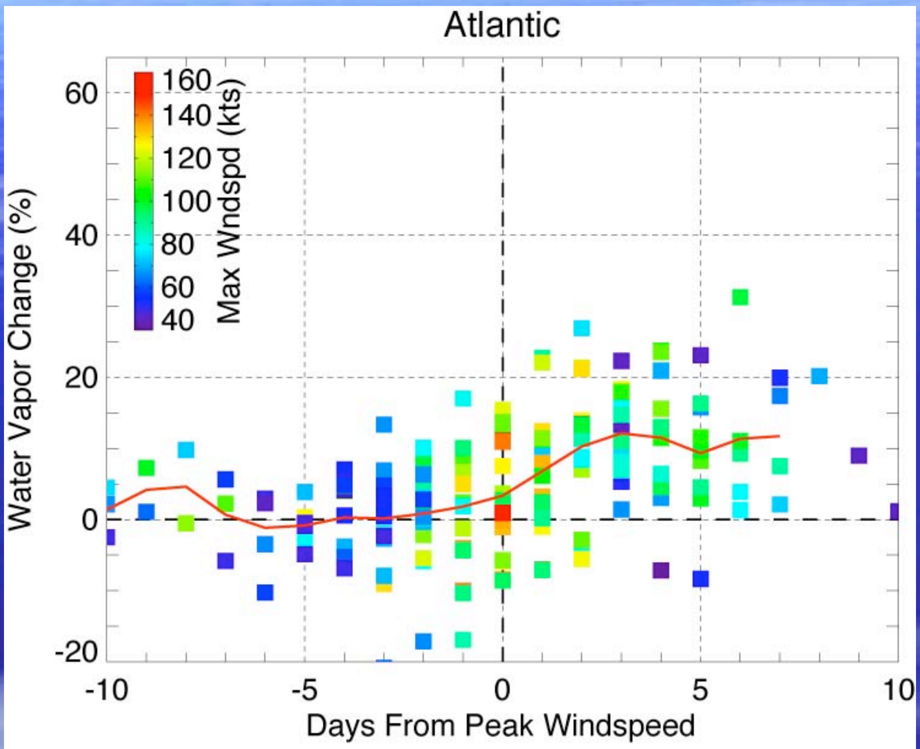
Large region of compensating decrease in high level cloudiness to the west of the cyclone centers.

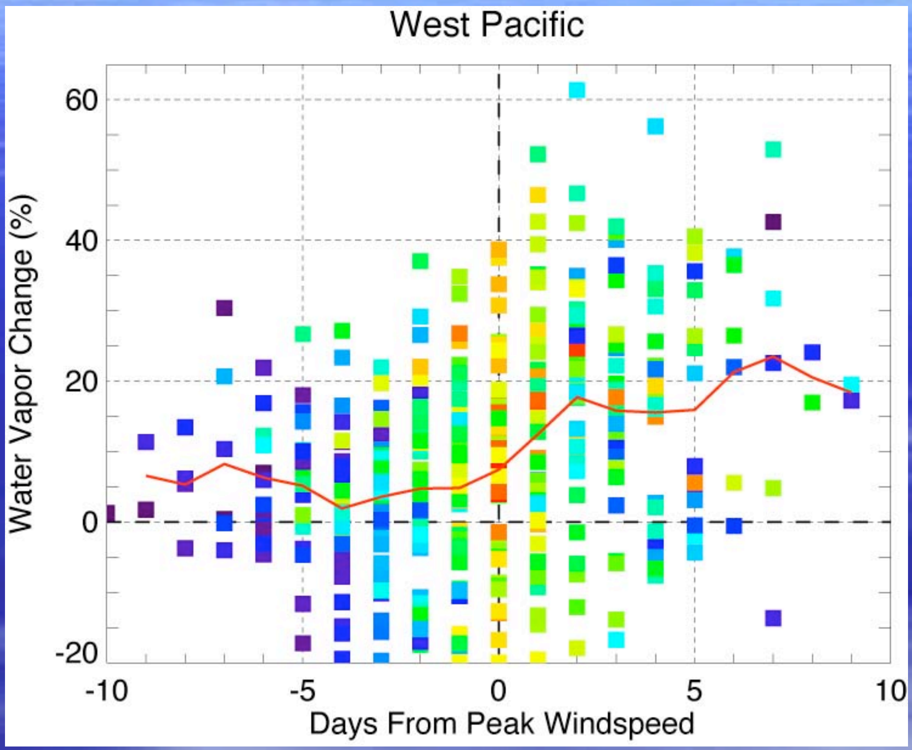
AIRS v5 Relative Humidity Differences
223 hPa   2004-05





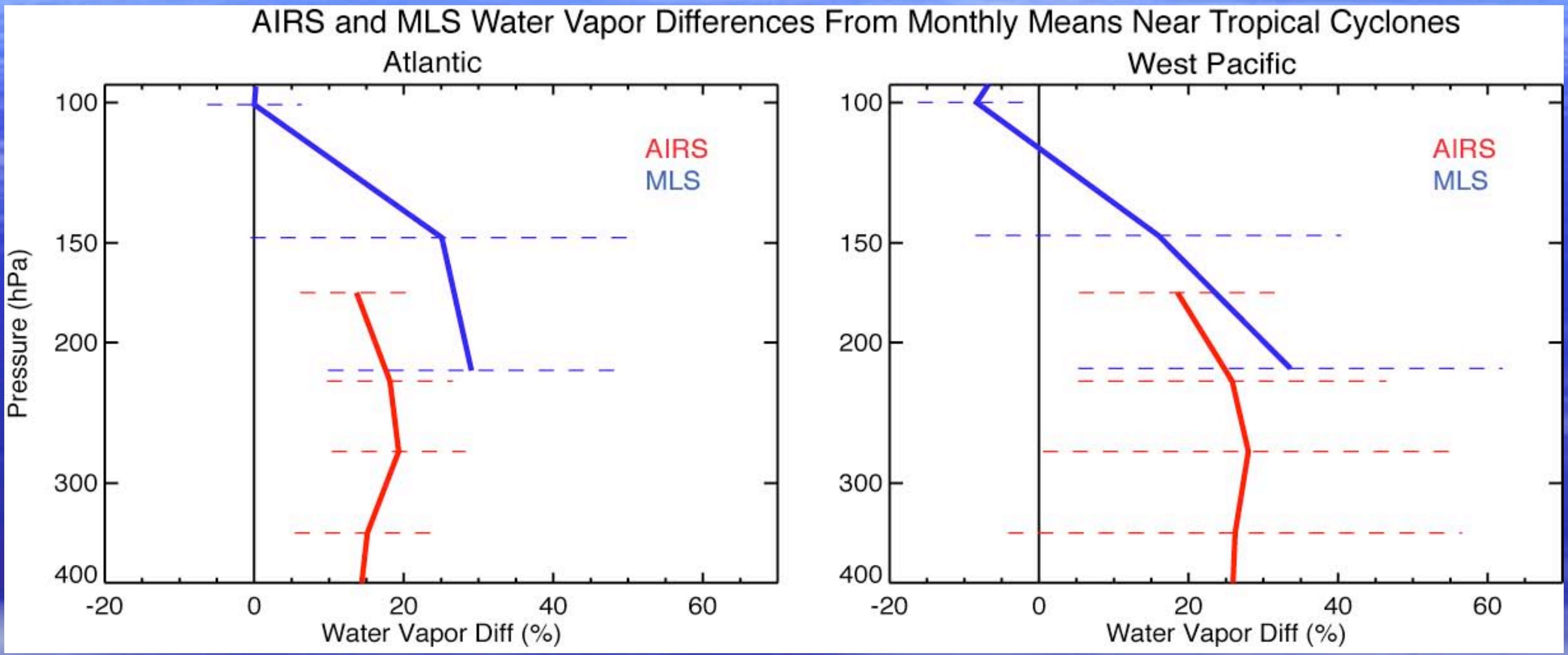
Time Evolution of Water Vapor Enhancement
223 hPa





Averages taken from 15 degree box around the eye each day.

AIRS and MLS Water Vapor Difference Profiles
2004-5 Intense Cyclones



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Significance to Tropical UT Water Vapor Budget?

Compare the TC contributions to total tropical UT (300-150 hPa) water vapor by:

$$F_i = \boxed{\frac{\chi_i A_i D_i}{\chi_T A_T D_T}}$$

where i = individual TC region

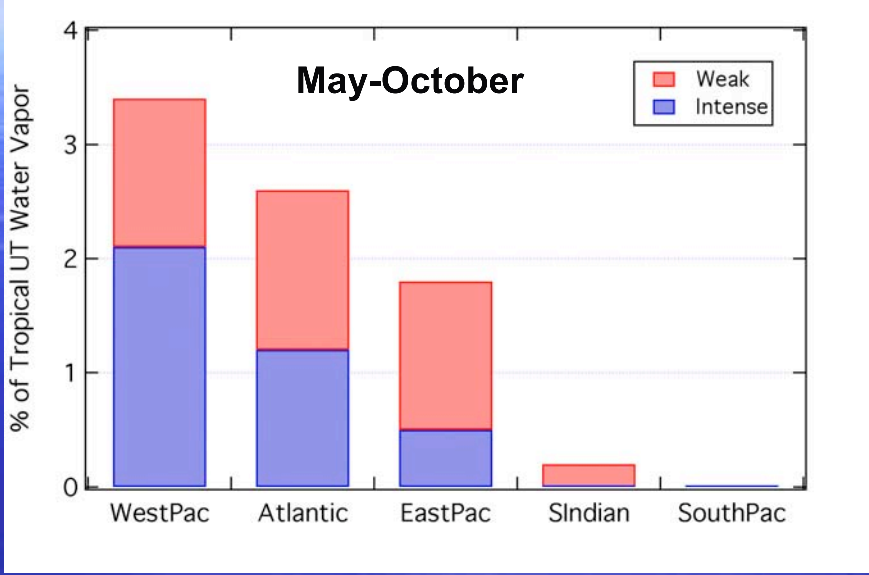
χ = water vapor mixing ratio

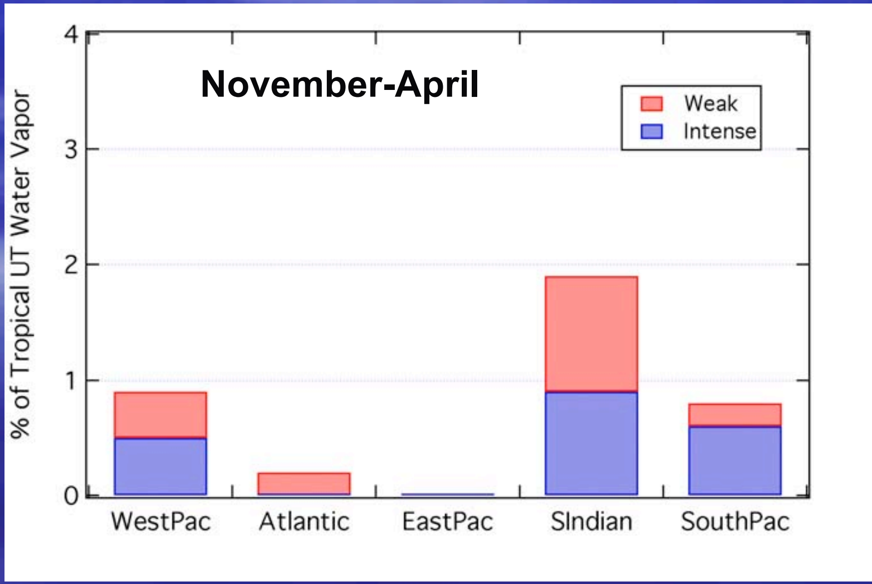
A_i = area around the eye (15˚ box)

A_T = area of the tropics (25˚S-25˚N)

D_i = average cyclone days in season

D_T = 182 days





Summary

- TCs effectively moisten and increase the cloud cover in the tropical UT.

- They appear to be a significant contributor to the global tropical UT WV budget.

- Warmer SSTs are likely to increase TC climate impacts.